3.2.4.4 *Wireless Control Signal*. The power supplied to a ballast using a wireless signal is not easily measured, but is estimated to be well below 1.0 watt. Therefore, the wireless control signal power is not measured as part of this test procedure.

4. *Calculations*.

4.1 Calculate relative light output:

$$\text{relative light output} = \frac{\text{Photocell output of lamp on test ballast}}{\text{Photocell output of lamp on reference ballast}} \times 100$$

Where: photocell output of lamp on test ballast is determined in accordance with section 3.1.4.2, expressed in watts, and photocell output of lamp on ref. ballast is determined in accordance with section 3.1.4.1, expressed in watts.

4.2. Determine the Ballast Efficacy Factor (BEF) using the following equations:

(a) Single lamp ballast

$$BEF = \frac{\text{relative light output}}{\text{input power}}$$

(b) Multiple lamp ballast

$$BEF = \frac{\text{average relative light output}}{\text{input power}}$$

Where:

Input power is determined in accordance with section 3.1.3.1, relative light output as defined in section 4.1, and average relative light output is the relative light output, as defined in section 4.1, for all lamps, divided by the total number of lamps.

4.3 Determine Ballast Power Factor (PF):

$$PF = \frac{\text{Input power}}{\text{Input voltage} \times \text{input current}}$$

Where:

Input power is as defined in section 3.1.3.1, Input voltage is determined in accordance with section 3.1.3.2, expressed in volts, and Input current is determined in accordance with section 3.1.3.3, expressed in amps.

[54 FR 6076, Feb. 7, 1989, as amended at 56 FR 18682, April 24, 1991; 69 FR 18803, Apr. 9, 2004; 70 FR 60412, Oct. 18, 2005; 74 FR 54455, Oct. 22, 2009; 76 FR 25223, May 4, 2011; 76 FR 70628, Nov. 14, 2011; 77 FR 4216, Jan. 27, 2012]

Appendix Q1 to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Fluorescent Lamp Ballasts

Comply with Appendix Q1 beginning November 14, 2014. Prior to this date, all fluorescent lamp ballasts shall be tested using the provisions of Appendix Q.

1. Definitions

1.1. *AC control signal* means an alternating current (AC) signal that is supplied to the ballast using additional wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.2. *Active Mode* means the condition in which an energy-using product—

(a) Is connected to a main power source;

(b) Has been activated; and

(c) Provides 1 or more main functions.

1.3. *Cathode heating* refers to power delivered to the lamp by the ballast for the purpose of raising the temperature of the lamp electrode or filament.

1.4. *Commercial ballast* is a fluorescent lamp ballast that is not a residential ballast as defined in section 1.13 and meets technical standards for non-consumer radio frequency lighting devices as specified in subpart C of 47 CFR part 18.

1.5. *DC control signal* means a direct current (DC) signal that is supplied to the ballast using additional wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.6. *High-frequency ballast* is as defined in ANSI C82.13 (incorporated by reference; see §430.3).

1.7. *Instant-start* is the starting method used instant-start systems as defined in ANSI C82.13 (incorporated by reference; see §430.3).

1.8. *Low-frequency ballast* is a fluorescent lamp ballast that operates at a supply frequency of 50 to 60 Hz and operates the lamp at the same frequency as the supply.

1.9. *PLC control signal* means a power line carrier (PLC) signal that is supplied to the ballast using the input ballast wiring for the purpose of controlling the ballast and putting the ballast in standby mode.

1.10. *Programmed-start* is the starting method used in programmed-start systems as defined in ANSI C82.13 (incorporated by reference; see §430.3).

1.11. *Rapid-start* is the starting method used in rapid-start type systems as defined in ANSI C82.13 (incorporated by reference; see §430.3).

1.12. *Reference lamp* is a fluorescent lamp that meets certain operating conditions as defined by ANSI C82.13 (incorporated by reference; see §430.3).

1.13. *Residential ballast* is a fluorescent lamp ballast designed and labeled for use in residential applications. Residential ballasts must meet the technical standards for consumer RF lighting devices as specified in subpart C of 47 CFR part 18.

1.14. *RMS* is the root mean square of a varying quantity.

1.15. *Standby mode* means the condition in which an energy-using product—

(a) Is connected to a main power source; and

(b) Offers one or more of the following user-oriented or protective functions:

(i) To facilitate the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer.

(ii) Continuous functions, including information or status displays (including clocks) or sensor-based functions.

1.16. *Wireless control signal* means a wireless signal that is radiated to and received by the ballast for the purpose of controlling the ballast and putting the ballast in standby mode.

2. ACTIVE MODE PROCEDURE

2.1. Where ANSI C82.2 (incorporated by reference; see §430.3) references ANSI C82.1–1997, the operator shall use ANSI C82.1 (incorporated by reference; see §430.3) for testing low-frequency ballasts and shall use ANSI C82.11 (incorporated by reference; see §430.3) for testing high-frequency ballasts. In addition when applying ANSI C82.2, ANSI C78.81 (incorporated by reference; see §430.3), ANSI C82.1, ANSI C82.11, and ANSI C82.13 (incorporated by reference; see §430.3) shall be used instead of the versions listed as normative references in ANSI C82.2.

2.2. Instruments

2.2.1. All instruments shall be as specified by ANSI C82.2 (incorporated by reference; see §430.3).

2.2.2. *Power Analyzer*. In addition to the specifications in ANSI C82.2 (incorporated by reference; see §430.3), the power analyzer shall have a maximum 100 pF capacitance to ground and frequency response between 40 Hz and 1 MHz.

2.2.3. *Current Probe*. In addition to the specifications in ANSI C82.2 (incorporated by reference; see §430.3), the current probe shall be galvanically isolated and have frequency response between 40 Hz and 20 MHz.

2.3. Test Setup

2.3.1. The ballast shall be connected to a main power source and to the fluorescent lamp load according to the manufacturer's wiring instructions and ANSI C82.1 (incorporated by reference; see §430.3) and ANSI C78.81 (incorporated by reference; see §430.3).

2.3.1.1.1. Wire lengths between the ballast and fluorescent lamp shall be the length provided by the ballast manufacturer. Wires shall be kept loose and not shortened or bundled.

2.3.1.1.1.1. If the wire lengths supplied with the ballast are of insufficient length to reach both ends of lamp, additional wire may be added. The minimal additional wire length necessary shall be added, and the additional wire shall be the same wire gauge as the wire supplied with the ballast. If no wiring is provided with the ballast, 18 gauge or thicker wire shall be used. The wires shall be separated from each other and ground to prevent parasitic capacitance for all wires used in the apparatus, including those wires from the ballast to the lamps and from the lamps to the measuring devices.

2.3.1.1.2. The fluorescent lamp shall meet the specifications of a reference lamp as defined by ANSI C82.13 (incorporated by reference; see §430.3) and be seasoned at least 12 hours.

2.3.1.2. The ballast shall be connected to the number of lamps equal to the maximum number of lamps the ballast is designed to operate.

2.3.1.3. The ballast shall be tested with a reference lamp of the nominal wattage listed in Table A of this section.

2.3.1.4. For ballasts that operate rapid-start lamps (commonly referred to as 8-foot high output lamps) with recessed double contact bases, a nominal overall length of 96 inches, and that operate at ambient temperatures of 20 °F or less and are used in outdoor signs (sign ballasts):

2.3.1.4.1. A T8 lamp in accordance with Table A of this section shall be used for sign ballasts that only operate T8 lamps.

2.3.1.4.2. A T12 lamp in accordance with Table A of this section shall be used for sign ballasts that only operate T12 lamps.

2.3.1.4.3. A T12 lamp in accordance with Table A of this section shall be used for sign ballasts that are capable of operating both T8 and T12 lamps.

TABLE A—LAMP-AND-BALLAST PAIRINGS AND FREQUENCY ADJUSTMENT FACTORS

Ballast type	Nominal lamp wattage	Lamp diameter and base	Frequency adjustment factor (β)	
			Low-frequency	High-frequency
Ballasts that operate straight-shaped lamps (commonly referred to as 4-foot medium bipin lamps) with medium bipin bases and a nominal overall length of 48 inches.	32 34	T8 MBP T12 MBP	0.94 0.93	1.0 1.0
Ballasts that operate U-shaped lamps (commonly referred to as 2-foot U-shaped lamps) with medium bipin bases and a nominal overall length between 22 and 25 inches.	32 34	T8 MBP T12 MBP	0.94 0.93	1.0 1.0
Ballasts that operate rapid-start lamps (commonly referred to as 8-foot-high output lamps) with recessed double contact bases and a nominal overall length of 96 inches.	86 95	T8 HO RDC T12 HO RDC	0.92 0.94	1.0 1.0
Ballasts that operate instant-start lamps (commonly referred to as 8-foot slimline lamps) with single pin bases and a nominal overall length of 96 inches.	59 60	T8 slimline SP T12 slimline SP	0.95 0.94	1.0 1.0
Ballasts that operate straight-shaped lamps (commonly referred to as 4-foot miniature bipin standard output lamps) with miniature bipin bases and a nominal length between 45 and 48 inches.	28	T5 SO Mini-BP	0.95	1.0
Ballasts that operate straight-shaped lamps (commonly referred to as 4-foot miniature bipin high output lamps) with miniature bipin bases and a nominal length between 45 and 48 inches.	54	T5 HO Mini-BP	0.95	1.0
Ballasts that operate rapid-start lamps (commonly referred to as 8-foot high output lamps) with recessed double contact bases, a nominal overall length of 96 inches, and that operate at ambient temperatures of 20 °F or less and are used in outdoor signs.	86 110	T8 HO RDC T12 HO RDC	0.92 0.94	1.0 1.0

MBP, Mini-BP, RDC, and SP represent medium bipin, miniature bipin, recessed double contact, and single pin, respectively.

2.3.2. Power Analyzer

2.3.2.1. The power analyzer shall have n+1 channels where n is the number of lamps a ballast operates.

2.3.2.2. *Lamp Arc Voltage*. Leads from the power analyzer should attach to each fluorescent lamp according to Figure 1 of this section for rapid- and programmed-start ballasts, Figure 2 of this section for instant-start ballasts operating single pin (SP) lamps, and Figure 3 of this section for instant-start ballasts operating medium bipin (MBP), miniature bipin (mini-BP), or recessed double contact (RDC) lamps. The programmed- and rapid-start ballast test setup includes two 1000 ohm resistors placed in parallel with the lamp pins to create a midpoint from which to measure lamp arc voltage.

2.3.2.3. *Lamp Arc Current*. A current probe shall be positioned on each fluorescent lamp according to Figure 1 for rapid- and programmed-start ballasts, Figure 2 of this section for instant-start ballasts operating SP lamps, and Figure 3 of this section for instant-start ballasts operating MBP, mini-BP, and RDC lamps.

2.3.2.3.1. For the lamp arc current measurement, the full transducer ratio shall be set in the power analyzer to match the current probe to the power analyzer.

$$\text{Full Transducer Ratio} = \frac{I_{in}}{V_{out}} \times \frac{R_{in}}{R_{in} + R_s}$$

Where:

I_{in} Current through the current transducer

V_{out} Voltage out of the transducer

R_{in} Power analyzer impedance

R_s Current probe output impedance

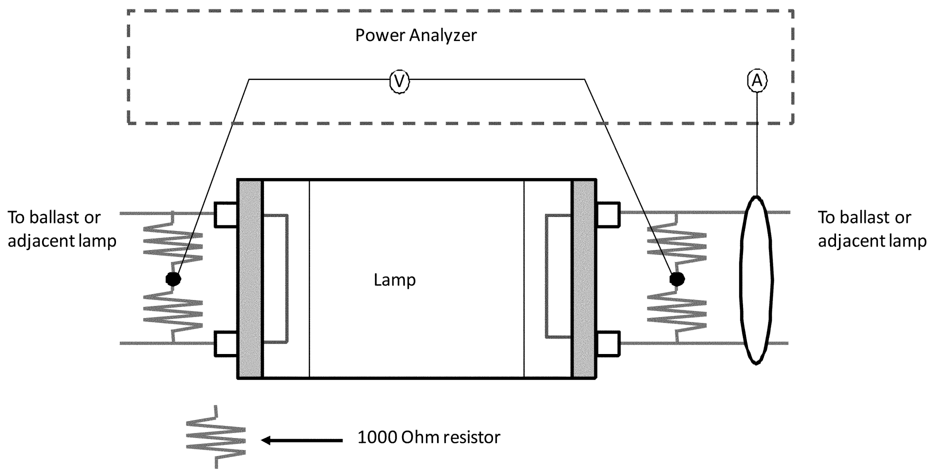

Figure 1: Programmed- and Rapid-Start Ballast Instrumentation Setup

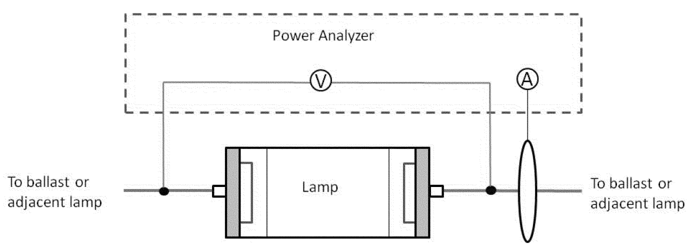

Figure 2: Instant-Start Ballasts that Operate SP Lamps Instrumentation Setup

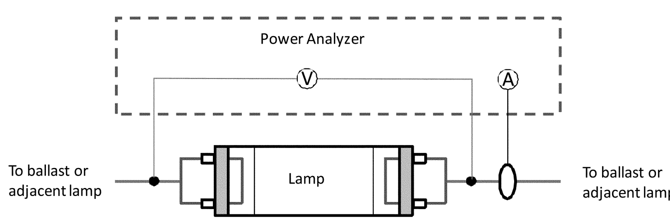

Figure 3: Instant-Start Ballasts that Operate MBP, mini-BP, and RDC Lamps Instrumentation Setup

2.4. Test Conditions

2.4.1. The test conditions for testing fluorescent lamp ballasts shall be done in accordance with ANSI C82.2 (incorporated by reference; see § 430.3). DOE further specifies that the following revisions of the normative references indicated in ANSI C82.2 should be used in place of the references directly specified in ANSI C82.2: ANSI C78.81 (incorporated by reference; see § 430.3), ANSI C82.1 (incorporated by reference; see § 430.3), ANSI C82.3 (incorporated by reference; see § 430.3), ANSI C82.11 (incorporated by reference; see § 430.3), and ANSI C82.13 (incorporated by reference; see § 430.3). All other normative references shall be as specified in ANSI C82.2.

2.4.2. *Room Temperature and Air Circulation.* The test facility shall be held at 25 ±2 °C, with minimal air movement as defined in ANSI C78.375 (incorporated by reference; see § 430.3).

2.4.3. *Input Voltage.* The directions in ANSI C82.2 (incorporated by reference; see § 430.3) section 4.1 should be ignored with the following directions for input voltage used instead. For commercial ballasts capable of operating at multiple voltages, the ballast shall be tested 277V ±0.1%. For ballasts designed and labeled for residential applications and capable of operating at multiple voltages, the ballast shall be tested at 120V ±0.1%. For ballasts designed and labeled as cold-temperature outdoor sign ballasts and capable of operating at multiple voltages, the ballast shall be tested at 120V ±0.1%. Ballasts capable of operating at only one input voltage shall be tested at that specified voltage.

2.5. Test Method

2.5.1. *Ballast Luminous Efficiency.*

2.5.1.1. The ballast shall be connected to the appropriate fluorescent lamps and to measurement instrumentation as indicated by the Test Setup in section 2.3.

2.5.1.2. The ballast shall be operated at full output for at least 15 minutes but no longer than 1 hour until stable operating conditions are reached. After this condition is reached, concurrently measure the parameters described in sections 2.5.1.3 through 2.5.1.9.

2.5.1.2.1. Stable operating conditions are determined by measuring lamp arc voltage, current, and power once per second in accordance with the setup described in section 2.3. Once the difference between the maximum and minimum values for lamp arc voltage, current, and power do not exceed one percent over a four minute moving window, the system shall be considered stable.

2.5.1.3. *Lamp Arc Voltage.* Measure lamp arc voltage (volts) using the setup described in section 2.3.2.2.

2.5.1.4. *Lamp Arc Current.* Measure lamp arc current (amps) using the setup described in section 2.3.2.3.

2.5.1.5. *Lamp Arc Power.* The power analyzer shall calculate output power by using the measurements described in sections 2.5.1.3 and 2.5.1.4.

2.5.1.6. *Input Power.* Measure the input power (watts) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see § 430.3), section 7.

2.5.1.7. *Input Voltage.* Measure the input voltage (volts) (RMS) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see § 430.3), section 3.2.1 and section 4.

2.5.1.8. *Input Current.* Measure the input current (amps) (RMS) to the ballast in accordance with ANSI C82.2 (incorporated by reference; see § 430.3), section 3.2.1 and section 4.

2.5.1.9. *Lamp Operating Frequency.* Measure the frequency of the waveform delivered from the ballast to any lamp in accordance with the setup in section 2.3.

2.6. Calculations

2.6.1. Calculate ballast luminous efficiency (BLE).

$$\text{Ballast Luminous Efficiency} = \frac{\text{Total Test Ballast Lamp Arc Power}}{\text{Ballast Input Power}} * \beta$$

Where: Total Lamp Arc Power is the sum of the lamp arc powers for all lamps operated by the ballast as determined by section 2.5.1.5, ballast input power is as determined by section 2.5.1.6, and β is equal to the frequency adjustment factor in Table A.

2.6.2. Calculate Power Factor (PF).

$$\text{Power Factor} = \frac{\text{Ballast Input Power} \times \text{Input Voltage}}{\text{Input Current}}$$

Where: Ballast input power is determined in accordance with section 2.5.1.6, input voltage is determined in accordance with section 2.5.1.7, and input current in determined in accordance with section 2.5.1.8.

3. STANDBY MODE PROCEDURE

3.1. The measurement of standby mode power need not be performed to determine compliance with energy conservation standards for fluorescent lamp ballasts at this time. The above statement will be removed as part of a rulemaking to amend the energy conservation standards for fluorescent lamp ballasts to account for standby mode energy consumption, and the following shall apply on the compliance date for such requirements.

3.2. Test Conditions

3.2.1. The test conditions for testing fluorescent lamp ballasts shall be done in accordance with the American National Standard Institute ANSI C82.2 (incorporated by reference; see §430.3). Any subsequent amendment to this standard by the standard-setting organization will not affect the DOE test procedures unless and until amended by DOE. The test conditions for measuring standby power are described in sections 5, 7, and 8 of ANSI C82.2. Fluorescent lamp ballasts that are capable of connections to control devices shall be tested with all commercially available compatible control devices connected in all possible configurations. For each configuration, a separate measurement of standby power shall be made in accordance with section 3.3 of the test procedure.

3.3. Test Method and Measurements

3.3.1. The test for measuring standby mode energy consumption of fluorescent lamp ballasts shall be done in accordance with ANSI C82.2 (incorporated by reference; see §430.3).

3.3.2. Send a signal to the ballast instructing it to have zero light output using the appropriate ballast communication protocol or system for the ballast being tested.

3.3.3. *Input Power*. Measure the input power (watts) to the ballast in accordance with ANSI C82.2, section 13, (incorporated by reference; see §430.3).

3.3.4. *Control Signal Power*. The power from the control signal path will be measured using all applicable methods described below.

3.3.4.1. *AC Control Signal*. Measure the AC control signal power (watts), using a wattmeter (W), connected to the ballast in accordance with the circuit shown in Figure 4 of this section.

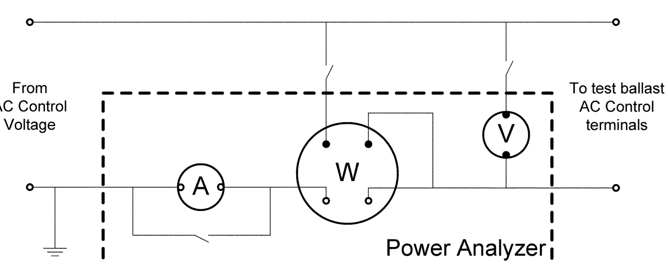

Figure 4: Circuit for Measuring AC Control Signal Power in Standby Mode

3.3.4.2. *DC Control Signal*. Measure the DC control signal voltage, using a voltmeter (V), and current, using an ammeter (A), connected to the ballast in accordance with the circuit shown in Figure 5 of this section. The DC control signal power is calculated by multiplying the DC control signal voltage and the DC control signal current.

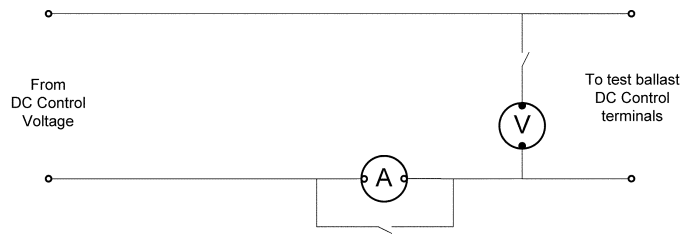

Figure 5: Circuit for Measuring DC Control Signal Power in Standby Mode

3.3.4.3. *Power Line Carrier (PLC) Control Signal*. Measure the PLC control signal power (watts), using a wattmeter (W), connected to the ballast in accordance with the circuit shown in Figure 6 of this section. The wattmeter must have a frequency response that is at least 10 times higher than the PLC being measured in order to measure the PLC signal correctly. The wattmeter must also be high-pass filtered to filter out power at 60 Hertz.

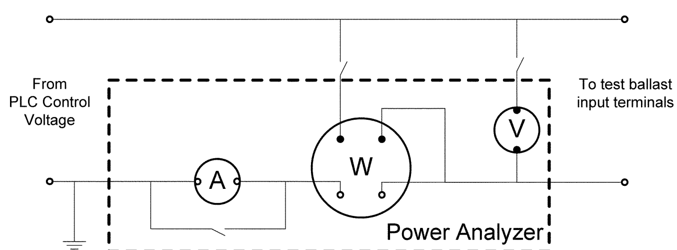

Figure 6: Circuit for Measuring PLC Control Signal Power in Standby Mode

3.3.4.4. *Wireless Control Signal*. The power supplied to a ballast using a wireless signal is not easily measured, but is estimated to be well below 1.0 watt. Therefore, the wireless control signal power is not measured as part of this test procedure.

[76 FR 25224, May 4, 2011, as amended at 76 FR 70628, Nov. 14, 2011; 77 FR 4217, Jan. 27, 2012]

Appendix R to Subpart B of Part 430—Uniform Test Method for Measuring Average Lamp Efficacy (LE), Color Rendering Index (CRI), and Correlated Color Temperature (CCT) of Electric Lamps

1. *Scope:* This appendix applies to the measurement of lamp lumens, electrical characteristics, CRI, and CCT for general service fluorescent lamps, and to the measurement of lamp lumens, electrical characteristics for general service incandescent lamps and incandescent reflector lamps.

2. *Definitions*

2.1 To the extent that definitions in the referenced IESNA and CIE standards do not conflict with the DOE definitions, the definitions specified in section 3.0 of IES LM–9 (incorporated by reference; see §430.3), section 3.0 of IESNA LM–20 (incorporated by reference; see §430.3), section 3.0 and the Glossary of IES LM–45 (incorporated by reference; see §430.3), section 2 of IESNA LM–58 (incorporated by reference; see §430.3), and Appendix 1 of CIE 13.3 (incorporated by reference; see §430.3) shall be included.

2.2 *ANSI Standard* means a standard developed by a committee accredited by the American National Standards Institute (ANSI).

2.3 *CIE* means the International Commission on Illumination.

2.4 *CRI* means Color Rendering Index as defined in §430.2.